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(54) Continuous and staple fibre preforms for reinforcing metals

(57) The invention provides a preform for use in the reinforcement of metal which preform comprises a first matrix of discontinuous fibres in conjunction with long or substantially continuous filaments disposed in a predetermined orientation thereover. Said preforms as described may interlock with other preforms similarly formed to form a single composite preform which is calcined at a temperature of at least 600°C. prior to positioning in a mould and being subjected to molten metal or infiltration of the same thereby.

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SPECIFICATION

Improvements in and relating to fibre reinforced preforms

5 This invention relates to the manufacture of shaped articles incorporating a high content of fibrous material and has particular reference to the manufacture of boards, sleeves, bricks and
10 other shapes. Shaped fibrous articles or preforms are frequently used for the reinforcement of metals. The fibres of such preforms are generally short, chopped fibres, or in the form of a fibre blanket in which the fibres are
15 arranged in a random manner in a blanket.

The use of continuous filaments, i.e. fibres having a length greater than say 2 cm have several advantages in the use of fibre reinforcement of metals since this provides an improved continuity of the reinforcement and much improved mechanical properties of the resulting cermet. It will be appreciated by the man skilled in the art that where fibrous preforms are used for metal reinforcement in for
20 example the manufacture of cermets, the fibrous content of the preform must be predominantly of a refractory fibre in order to prevent decomposition and undue gasing when the hot molten metal is cast about the preform.
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The use of continuous filaments in the reinforcement of metals presents a difficulty because of the retention of those filaments in a desired orientation while the metal is caused
35 to infuse or permeate interstices or spaces between adjacent filaments. Many attempts have been made to orient continuous or long filaments in this way, but as the metal is cast around the filament array, disturbance of the filaments occur such that the desired orientation cannot be obtained in a reproducible
40 manner.

According to the present invention, therefore, there is provided a preform for use in the reinforcement of metal which preform
45 comprises a matrix of short fibres accommodating within said matrix continuous filaments disposed in a predetermined orientation. The short fibres within the matrix are preferably
50 oriented in one direction and the continuous filaments are disposed therein either in the general direction of orientation of the short fibres or substantially transverse thereto.

By producing a preform in the manner described above, the continuity of the preform due to the presence of the continuous filaments is much greater and hence preforms of much lighter density than hitherto can be produced. This in turn allows during casting easier
60 access of the metal into the preform to form a finished article.

In an alternative embodiment of the present invention, a preform may be formed by known methods and continuous filaments may be
65 wound or otherwise disposed on the surface

of the preform prior to the introduction of the metal layer.

The present invention also includes a method of forming a preform for use in the
70 reinforcement of metals which method comprises incorporating long or substantially continuous filaments therein, which filaments are supported by a matrix of a short fibre composition. A part preform may be formed by preparing a slurry of a short fibre composition,
75 introducing the slurry into a mould, pressing the slurry to expel liquid therefrom in one direction to obtain substantial orientation of the short fibres arranging the continuous filaments in a desired orientation juxtaposition to the
80 surface of a part preform so formed, applying a second part preform thereto to form the completed shape and drying the completed preform so formed. An additional pressing stage may be provided and after drying the preform may be calcined at an elevated temperature.
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In an alternative embodiment of the present invention, the second part preform may be
90 applied by forming in said second part *in situ*. This may be effected by introducing a further quantity of slurry into the mould, pressing said further quantity of slurry to remove liquid therefrom in one direction to produce substantially
95 uniform orientation of the short fibres therein, thus serving to sandwich the continuous filaments between the two parts of the preform thus formed thus forming a substantially continuous matrix thereabout. After the pressing,
100 the preform is removed from the mould and dried and thereafter calcined at an elevated temperature.

In yet a further embodiment of the present invention the long or continuous filaments may
105 be included in an aqueous slurry within a mould and the contents of the mould then subject to dewatering in one direction to orient the short fibres within the composition to produce a shaped preform having said long or continuous filaments dispersed in a matrix of
110 said short fibre composition.

In a further embodiment of the present invention, two separate part preforms may be produced which are adapted to mate to form the desired preform and long or continuous
115 filaments may be disposed between the two parts in a predetermined array before the parts are put together to form the final preform.

In the reinforcement of metal, the fibrous content of the preform matrix is substantially inorganic fibres and preferably, synthetic inorganic fibres. The use of these synthetic inorganic fibres has the advantage of minimising the number of additives particularly organic
120 additives necessary to obtain shape maintenance of the composition on forming and further reduces the amount of water likely to be absorbed in a material which will require removal prior to calcining at an elevated temperature.
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ature.

Man-made inorganic fibres suffer from the disadvantage that unlike their organic counterparts they are more difficult to maintain in suspension to obtain the required degree of orientation of the fibres on formation of the shaped articles.

In accordance with the present invention, preformed compositions that have been traditionally employed are used to provide the support for the continuous filament reinforcement for use in the metal composite or cermet. The production of the preform composition comprises short lengths (up to two, or to a maximum of 15 centimetres) with a binding agent and forming a mixture of fibres and binding agents into a slurry, introducing said slurry into a mould, pressing the slurry to expel the slurry liquid therefrom in one direction to obtain orientation of the short fibres in a resultant shaped article, introducing the continuous filaments into the mould in a desired orientation, reintroducing a further aliquot of the slurry composition into the mould, further pressing to expel slurry liquid therefrom, thereby incorporating the continuous filaments in a matrix of short fibre composition, continuing pressing until the preform has a self-sustaining shape, drying the preform so formed and thereafter calcining at an elevated temperature.

The composite fibre filament preform thus formed has the advantage that continuous filaments can be maintained in positions and orientations which give the required properties to the resultant castings without having to be dispersed generally throughout components which normally incur higher costs and may confer unwanted properties in particular areas. Expensive filaments can be accurately located in areas which will benefit most from them.

Preheated fibre preforms will thermally insulate continuous filaments inside them against heat loss which could otherwise be substantial during the transfer of the preform from the preheating furnace of a casting machine. The heat loss from the fibre preforms is less critical than heat loss from the continuous filaments because fibres can be infiltrated with metal at low temperatures, indeed even at room temperature.

Fibres or filaments which reduce corrosion resistance if they break through the surface composite such as fibres of boron and carbon, can be held away from the casting surfaces by positioning a layer of fibre composition near the surface which latter does not reduce corrosion resistance.

Furthermore, aluminium alloy composites with alumina fibres at the surface can be readily anodised. Filaments held in place in fibre preforms do not reduce or eliminate the requirement for bonding agents. Bonding agents can interfere with metal to fibre interactions at the fibre surface and within the interstices of

the preform and thus can reduce composite properties. While fibre preforms are mainly used to hold the filaments in position in castings, they also contribute to improvements in properties in the final component.

Some metal to filament composites cannot be readily shaped by conventional workshop tools. Metal/ceramic fibre composites are more easily shaped. In accordance with the invention, the filaments can be held in place in the castings in positions which will not require machining so that shaping need only be carried out on parts of the castings reinforced with fibre alone.

Typical filaments for use in accordance with the present invention are boron filaments, carbon filaments and continuous filaments of magnesium, boron and silicon carbide.

The fibrous composition to be used as a matrix from which these supporting preforms are formed, may comprise any inorganic fibrous material having a melting point greater than 1000°C. Typical inorganic fibres may be selected from fibres of alumina, magnesia, boron, silicon carbide and carbon. These fibrous materials are mixed with an inorganic binder which may be typically selected from colloidal silica, colloidal alumina, acids and salts of phosphorus and chromium. The inorganic fibre may also be used in conjunction with an inorganic binder and typical organic binders are selected from starch, cellulose fibre, gums and synthetic resin. Where the organic fibre is a cellulosic fibre, this may be comminuted newspaper.

The slurry is preferably an aqueous slurry and the compression ratio within the pressing step is within the range 2:1 to 10:1. Because of the difficulty of maintaining inorganic fibres in suspension, the pressing and shaping process is preferably characterised by introducing the slurry into a mould and subjecting the slurry therein to a hydrostatic pressure to a predetermined threshold without substantial settlement of the slurry solids taking place, further pressing at a pressure above said threshold accompanied by monoaxial orientation and deposition of the fibres whereby the rate of deliquification is controlled so that at least 95% of the fibres have an orientation within 15° of said axis.

The threshold pressure to which the slurry is subjected prior to substantial deliquification taking place is preferably at least 20% of the final pressure exerted on the solid constituents of the slurry. The threshold pressure maintained during the deliquification of the slurry should produce a balance between the applied pressure at or above the threshold and the rate of deliquification necessary to obtain to obtain the maximum fibre orientation, thus obtaining the maximum improvement in properties of the shaped fibre mat. In a further embodiment, more than 50% of the pressure finally applied may constitute the threshold pres-

sure and pressures even greater than 80% to the final applied pressure may be employed. The upper limit of pressing is that at which under pressure alone, the fibres alter significantly their characteristics and properties.

After pressing and shaping, the preform so formed is dried and subsequently calcined at at least 600°C to remove any organic constituents.

Thereafter, the preform may be used to form a metal composite and the metal material may be introduced in the product in order to produce a strong cermet composition. The introduction of the metal may be effected by any conventional casting processes such as squeeze casting, die-casting, sand casting and vacuum infiltration/gas pressurization.

In a typical example, a composite of alumina fibre reinforced aluminium may be prepared in which the composite has between 20 and 30% of final composite weight of fibre content. The liquid metal is introduced into the shaped preform to penetrate the interstices of the fibrous mat and surround the filament reinforcement therein. The temperature of the metal and the pressures applied may be varied depending on the particular circumstances and the density of the preformed thus formed.

One advantage of the present invention is that the structural strength of the preforms thus formed are significantly improved. This results in the possibility of the production of preforms having much reduced densities and yet still maintaining their structural continuity under conditions under which metal is introduced in the fibre/filament interstices within the preform. As a result, the metal penetration of the preform is much more easily effected and in consequence this allows the possibility of gravity casting techniques in the formation of cermets.

CLAIMS

1. A preform for use in the reinforcement of metal which preform comprises a first matrix of discontinuous fibres in conjunction with continuous filaments disposed in a predetermined orientation relative thereto.

2. A preform according to claim 1 wherein the continuous filaments are wound about the exterior of the first discontinuous matrix.

3. A preform according to claim 1 wherein the continuous filaments are orientated into the predetermined orientation by dewatering from an aqueous slurry in a single direction.

4. A preform according to any preceding claim wherein a second discontinuous matrix overlies the first discontinuous matrix and the continuous filaments disposed thereupon.

5. A preform according to any preceding claim wherein two preforms according to claim 1 are adapted to be interlockable to form a single composite preform.

6. A preform according to any preceding claim further including an inorganic or organic

bonding agent selected from colloidal silica, colloidal alumina, acids and salts of phosphorus or chromium, starch, cellulosic fibres, gums or synthetic resins.

7. A preform according to any preceding claim wherein the fibres are selected from alumina, alumino silicate, boron, silicon carbide, or carbon.

8. A method of forming a preform for use in the reinforcement of metal, said preform comprising long or substantially continuous filaments in a matrix overlying discontinuous fibres, which method comprises preparing a slurry of discontinuous fibres, introducing said slurry into a mould, pressing said slurry to expell liquid to give a first discontinuous preform, orientating continuous filaments in juxtaposition to the so formed preform, and, drying the so formed preform.

9. A method of forming a preform for use in the reinforcement of metals which preform comprises long or substantially continuous filaments in a matrix overlying discontinuous fibres, which method comprises preparing a first mat or blanket of discontinuous fibres, inter-engaging said first mat or blanket with a plurality of overlying long or substantially continuous fibres, orientated in a predetermined direction, thereby to form a preformed composite.

10. A method according to claim 6 or 9, wherein a second discontinuous preform is formed over said so formed preform to form a sandwich construction.

11. A method according to any of claims 6 to 10, further including a calcining step at an elevated temperature of at least 600°C.

12. A method according to claim 10 when dependent upon claim 8, wherein the second discontinuous preform is formed by introducing a further quantity of slurry into the mould, pressing said quantity to remove liquid, thereby to form a substantially orientated discontinuous matrix thereabout.

13. A method according to claim 12 wherein the first and/or second slurry is dewatered unidirectionally to orientate the discontinuous fibres.

14. A method according to any of claims 6 to 13, wherein the fibres are preheated prior to infiltration with a liquid metal.

15. A casting process which comprises introducing a preform according to any of claims 1 to 7 or made by a process of any of claims 8 to 14 into a die, casting a metal thereabout, to cause said metal to infiltrate said preform.

16. A preform substantially as hereinbefore set forth with reference to and/or as illustrated in the accompanying drawings.

17. A method for the preparation of a preform substantially as hereinbefore set forth with reference to, and/or as illustrated in the accompanying drawings.

18. A method of casting, utilizing a preform

substantially as hereinbefore set forth with reference to, and/or as illustrated in the accompanying drawings.

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